INTEGRATION OF DYNAMIC WEATHER ROUTES AUTOMATION WITH AIR/GROUND DATA COMMUNICATIONS

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Abstract

The Dynamic Weather Routes (DWR) tool continuously and automatically analyzes airborne flights in en route airspace to identify flights where a route correction could save significant flight time and still avoid weather. A partnership between NASA, American Airlines (AA), and the FAA has enabled testing of DWR in real-world air traffic operations. En route Data Communications (Data Comm) could significantly reduce the controller and pilot workload needed to communicate DWR route changes under today's voice-based operations and thereby enable more timely and frequent high-value corrections to weather avoidance routes. Sample data from the DWR trial at AA illustrate how Data Comm could improve DWR operations. Two operating concepts that integrate DWR with Data Comm are described: (1) route corrections are initiated by air traffic control and implemented using Airborne Reroutes and Data Comm, and (2) route corrections are initiated by the dispatcher and pilot and implemented via Data Comm. Both concepts align with Federal Aviation Administration (FAA) plans for implementation of Data Comm in en route airspace.

Introduction

Convective weather is the leading cause of delay in US airspace. Airline dispatchers file their flight plans 1-2 hours before take off, and are often required to incorporate large buffers to avoid forecasted weather. Weather changes as flights progress, and dispatchers and FAA traffic managers and controllers are especially busy during adverse weather events. Workable opportunities for more efficient routes around bad weather are missed, and automation does not exist to help operators determine when weather avoidance routes have become stale and could be updated to reduce delay.

The Dynamic Weather Routes (DWR) tool is a ground-based trajectory automation system that continuously and automatically analyzes airborne flights in en route airspace in context with local weather information to identify flights that could significantly benefit from a route correction [1-4]. Data from the operational use of a prototype DWR system at American Airlines (AA) demonstrate benefits of about 3,290 min flight-time saved for 526 flights for one airline (AA) in one en route Center (Forth Worth) over 21 months of operations. Of these, 48 flights each show an estimated savings of 15 min or more. Assuming an operating cost of $75/min, this equates to an annualized savings of about $140,000 in operating cost for one airline in one Center.

Although significant, the benefits realized to date pale in comparison to the potential benefits identified by DWR. Due to dispatcher workload and a limited integration of DWR automation with dispatcher automation, only 22% of DWR advisories for AA flights in Fort Worth Center (ZFW) were evaluated by dispatchers during the Jan 2013 through Sept 2014 period. And of those evaluated and rated acceptable by dispatchers and sent to flight crews as route change proposals, only 37% of proposed savings were observed in Center route amendments for AA flights.

This paper explores the feasibility of capturing a higher percentage of the benefits by integrating DWR automation with en route Data Communications (Data Comm). The single most important benefit that Data Comm is expected to bring to DWR is the enabling of timely, low-workload communication of high-value route change opportunities between controllers, pilots, and dispatchers [5]. Intuitive user inputs, e.g., button presses, let users auto-load route change information into their respective systems and see a graphic display of the proposed route change with relevant weather, and for controllers and dispatchers, with relevant weather and traffic. Data Comm-enabled communication is much simpler and more effective than today's voice-based communication and should enable more timely and more frequent corrections to weather avoidance routes. The resulting savings is expected to help establish the business case for Data Comm equipage in US domestic en route airspace.

The paper is organized as follows. A background section summarizes the DWR automation concept, the operational trial at AA, and the FAA's en route Data Comm program. The next section uses sample data from the AA trial to illustrate how Data Comm could streamline the dispatcher/pilot/controller coordination process and likely result in more savings. Rough estimates of the additional DWR savings that could be realized with Data Comm are provided. The compatibility of DWR route corrections with Data Comm messaging is described. Two operating concepts that integrate DWR with en route Data Comm are described: (1) route corrections are initiated by ATC and implemented using Airborne Reroutes (ABRR) [6] and Data Comm, and (2) route corrections are initiated by the dispatcher and pilot and implemented via Data Comm. Both concepts align with FAA plans for Data Comm in en route airspace.

Background

DWR Automation Concept

The main features of the DWR concept are: 1) automation continuously analyzes airborne flights and alert users to high-value route correction opportunities, 2) straight-forward route amendments based on minimum-delay resolution of weather conflicts or optionally weather and traffic conflicts are proposed, 3) airspace congestion metrics are incorporated so that congestion on the current route and corrected route may be compared, and 4) simple button clicks on the user interface show a graphic display of the proposed route correction with relevant weather and traffic. The real-time search of airborne flights is important because airborne flights are closer to impacting weather and the likelihood of workable opportunities for more efficient routes is higher. The DWR automation concept and system are described in [1]. Test results and improvements to the search algorithm, automation system, and operating concept are described in [2, 3, 4].

The DWR search algorithm continuously analyzes all flights in en route airspace. It first detects flights with large course changes or "dog-legs" in their current Center flight plan routes. Large course changes in the current route of flight are a strong indication that a flight is on a weather avoidance route. A direct route to a downstream flight plan fix that eliminates the dog-leg, but is not too far downstream, is tested for wind-corrected flying time savings and probed for weather and traffic conflicts. Auxiliary waypoints, up to two, are automatically inserted as needed to avoid weather and (optionally) traffic. If a solution for a flight is found that can save a user-specified minimum number of flying min (5 min default), a route correction alert is posted to a user display. In the AA system an important element of the operating concept is an audible tone (that of an old-fashioned cash register, "ka-ching") that alerts otherwise busy users to a route correction opportunity for a new flight. A simple point and click action shows a graphic display of the current route, the proposed route correction, relevant weather and traffic, sector congestion metrics, and relevant special-use airspace and FAA route restrictions.

As shown in Figure 1, all DWR route corrections are defined by three key parameters: a maneuver start point (MSP), a downstream return capture fix (CAPFX), and up to two auxiliary waypoints (AUXWPT). All parameters are computed automatically by the DWR system. A limit function selects the return capture fix such that route changes do not deviate too far from the current route of flight or interfere with arrival routings at the destination airport [1]. The MSP is located an adjustable number of minutes downstream of present position on the current flight plan trajectory. This enables the anticipated coordination delay to be incorporated into DWR trajectory calculations. The default MSP is set to 5 min downstream of present position, or the first point in high altitude airspace. Auxiliary waypoints, up to two, are inserted as needed to achieve a minimum delay trajectory around forecast convective weather cells, and optionally to achieve an integrated resolution to weather and traffic conflicts. Trajectory calculations account for the forecasted movement of weather cells over future time.

[1] In the current DWR for ZFW, the return capture fix must be inside a rectangle that extends about 200 nmi beyond the Center boundary, and must be no further downstream than the last fix before the Standard Arrival Route to the destination airport.

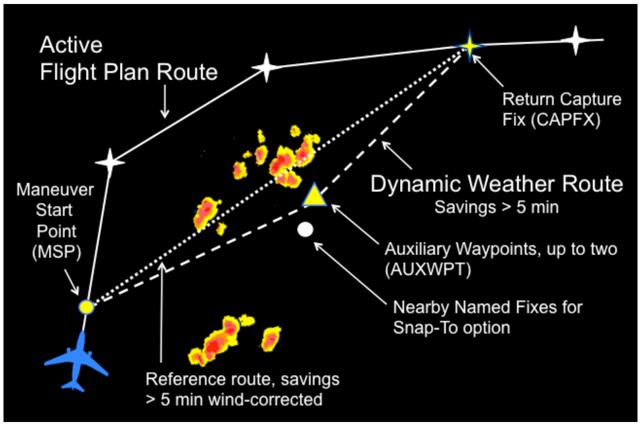

Figure 1. DWR Concept

The DWR user interface, shown in Figure 2, includes a traffic display and a list of flights for which successful DWR solutions have been computed. DWR users are alerted when a route correction for a flight can potentially save a user-specified minimum number of flying minutes. An interactive trial planning function enables users to visualize DWR routes and modify them if necessary. Critical parameters such as weather proximity, wind-corrected flying time savings, traffic conflicts, sector congestion, special use airspace, and FAA routing restrictions are all shown and update dynamically as the user modifies the trial route using interactive point, click, and drag inputs.

Figure 2. DWR User Interface

The primary inputs to the DWR system are en route Center radar track and flight plan data (12-sec updates), National Oceanic and Atmospheric Administration Rapid Refresh wind, temperature, and pressure data (hourly updates), the Corridor Integrated Weather System (CIWS) convective weather forecast model (5-min updates, 2-hour forecast look-ahead, 5-min time steps) [7], the Convective Weather Avoidance Model (CWAM) [8], and the Traffic Flow Management System (TFMS) national traffic feed (1-min updates). The CWAM model uses CIWS output as its primary input and generates weather avoidance polygons that model the probability of pilot deviation for weather as a function of storm intensity and echo tops. DWR advisories update every 12 sec as fresh Center radar track and flight plan data are received.

When auxiliary waypoints are needed, DWR first computes waypoints in fix-radial-distance (FRD) format. Then, if the snap-to-fix option is selected, FRD auxiliary waypoints are replaced by the set of nearby named fixes that results in a minimum-delay trajectory (relative to the FRD trajectory) while still avoiding forecast weather cells. For the AA trial, the snap-to-fix option is always activated, and eligible snap-to fixes are all three-letter waypoints as defined in the 56-day En Route Automation Modernization

(ERAM) adaptation updates plus all National Reference System (NRS) waypoints (e.g., the "K" fixes) [2].

Trial at American Airlines

NASA and AA have been conducting a trial of DWR tool at AA's Integrated Operations Center (IOC) in Fort Worth, Texas since July 2012. The tool runs at a position called the Air Traffic Control (ATC) Desk on the IOC operations floor [2, 4]. An audible tone alerts AA users, ATC Coordinators, who are also licensed dispatchers, whenever a route correction for a new AA flight is first posted to the flight list on the user display (see Figure 2). If the ATC Coordinator concurs with a DWR advisory, he or she coordinates it with the dispatcher in charge of the flight. If they both agree, the ATC Coordinator clicks "Accept" on the user display, and the dispatcher sends a free-text message (via the Aircraft Communications, Addressing, and Reporting System, or ACARS) to the flight crew proposing the route change for time and fuel savings. If the flight crew concurs, they request the route change from Center ATC using normal procedures. Testing is limited to AA flights in ZFW airspace, and since adjacent Center processing was installed on May 9, 2014, AA flights in ZFW plus its first tier adjacent Centers (Kansas City, Memphis, Houston, and Albuquerque).

As described earlier, only 22% of DWR advisories were evaluated by AA dispatchers. Sixty-two percent (62%) of DWRs evaluated by AA were rated accept by dispatchers, and most of these (85-95%) were sent to flight crews as proposed route changes. Thirty-seven percent (37%) of savings that was accepted and sent to flight crews resulted in actual savings for AA flights.

It is expected that if Data Comm were in place, all of these percentages would rise due to the reduction in controller, pilot, dispatcher, and traffic manager workload offered by Data Comm.

Data Communications

The purpose of Data Comm is to enhance safety and efficiency in the National Airspace System (NAS) by improving the accuracy of air/ground (A/G) communications and reducing controller and pilot workload [5]. In today's operations pilot/controller voice communications represents a significant portion of the sector controller's workload. Voice communications are often the limiting factor in sector throughput. With Data Comm in en route airspace, A/G communications can be split between the primary radar (R-side) controller and the radar associate (D-side) controller, and communication task times can be significantly reduced. Read-back and hear-back errors are eliminated since the pilot has a digital copy of a controller clearance, and the controller has digital copy of a pilot request. This reduction in controller workload leaves more time for frequent and timely response to flight time and fuel saving route change opportunities.

Data Comm requires aircraft avionics to be in compliance with the Future Air Navigation System (FANS)-1/A+ standard[2] which supports air/ground digital communication using the Controller/Pilot Datalink Communication (CPDLC) message set. Most, if not all, aircraft that fly oceanic routes today are FANS-1/A equipped and communicate with oceanic air traffic control (ATC) using CPDLC. It is expected that as Data Comm begins operations in domestic en route airspace, and when the business case for equipage is established, more aircraft will be equipped with the FANS-1/A+ avionics standard.

The FAA and industry partners have successfully conducted trials to demonstrate the benefit of Data Comm for delivery of departure clearance and revised departure clearance messages using FANS-1/A equipage with CPDLC messaging [9]. The next phase of the FAA Data Comm work examines the use of Data Comm for en route airspace operations.

Benefits of Data Comm-Enabled DWR

It is expected that en route Data Comm would greatly simplify the necessary communication between controllers, pilots, traffic managers, and dispatchers. This would enable more DWR advisories to be processed with lower processing delays and more savings. As described earlier, the workload reduction is to a large extent enabled by simple button presses that auto-load route change information into graphic displays, and communication systems that enable fast and efficient communication between agents. Savings are also

[2] The "+" in FANS-1/A+ indicates functionality for latency checking of uplink messages.

enabled by simplified processing of auxiliary waypoints inserted to achieve more efficient routes around weather.

In this section a subset of data from the AA trial are examined to help illustrate how Data Comm could simplify processing and coordination and enable more savings.

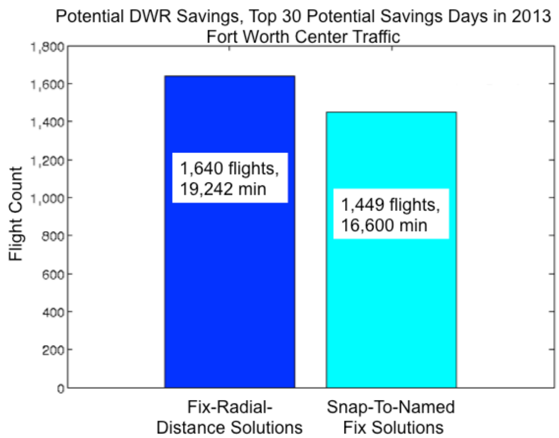

Figure 3. FRD vs. Snap-To-Fix, ZFW Flights, Top 30 Potential Savings Days in 2013

Since Data Comm does not require the use of named fixes, we examine the potential savings difference between DWR FRD solutions and snap-to-named-fix solutions. Figure 3 compares potential savings of DWRs computed using FRD auxiliary waypoints vs. potential savings of DWRs where FRD waypoints were replaced by nearby named fixes. All ZFW flights during the top 30 days in 2013 in terms of DWR potential savings are analyzed; these are generally the heavy weather days. For any given flight ID for which a DWR was computed (on a single day), the first of 3 consecutive DWR solutions in 45 seconds contributes to the overall savings shown in Figure 3. The DWR solution must have a potential savings of 5 min or more to be counted.

The bar graph shows that 191 (13%) more flights get DWR advisories with 2,642 (16%) minutes of additional potential savings when FRD solutions are used vs. snap-to-named-fix solutions. Some of the difference is due to savings loss between FRD and snap-to solutions for any given flight, and some of the difference is due to flights where a successful snap to solution is not found, or where the snap-to solution drops the DWR savings below the 5-min minimum savings criteria. Of course this savings difference is heavily dependent on the set of nearby named fixes eligible for snap-to solutions. The data in Figure 3 are based on eligible snap-to fixes being all three-letter fixes plus the NRS waypoints.

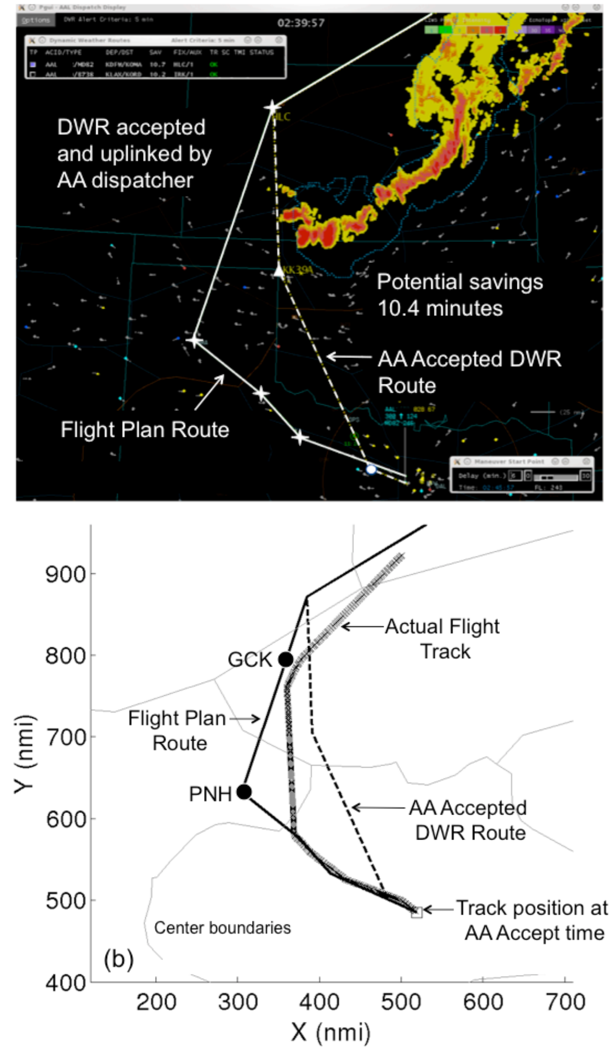

Figure 4. Sample Flight from AA Trial, (top) Dispatcher Accepted Route, (bottom) Actual Aircraft Track

The sample flight shown in Figure 4 serves to illustrate some of the limitations of current voice-based DWR operations and the improvements that could be enabled by Data Comm. Figure 4 (top) shows the route correction proposed by DWR and accepted and uplinked to the flight crew by the AA dispatcher. Figure 4 (bottom) shows the actual track of the flight. In this case the flight was issued a direct route to PNH 13 min after the AA user "accept" time and another direct route to GCK 24 min after the accept time. The total estimated actual savings for the flight was 4.8 min or about half of the savings proposed by the AA dispatcher. Several factors could have contributed to the delayed clearance and the actual track for this flight being quite different than the DWR route proposed by the AA dispatcher. These include pilot workload associated with typing in the auxiliary waypoint, controller preference for issuing direct routes, controller workload associated with processing route changes that include auxiliary waypoints (even when they are named waypoints) or traffic in the downstream sectors.

For every flight where an AA user clicks the "Accept" button signaling their intent to send an ACARS message to the flight, observed Center route amendments that occur up to 30 min after the accept time are analyzed to determine estimated actual savings for the flight [4]. Figure 5 shows the total accepted (attempted) savings and the total estimated actual savings for 70 AA flights with accepted DWR savings of 10 min or greater. The 70 flights are from the period starting on 5/9/2014 when processing of adjacent Center traffic was first activated [4] through 9/30/2014. Here we chose only flights with AA accepted savings of 10 min or more because these cases are more likely due to weather reroutes. On some days strong head winds on a departure procedure trigger DWR alerts with savings between 5 and 10 min.

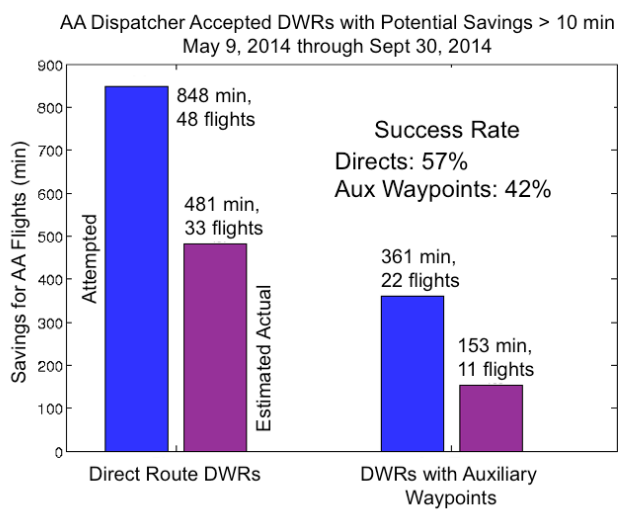

Figure 5. Attempted & Estimated Actual Savings for 70 Flights with Attempted Savings > 10 min

Direct route DWRs are distinguished from those with auxiliary waypoints in order to determine if more actual savings result from the simpler direct route advisories. Note from the attempted savings (blue) bars that about one-third of accepted DWR routes include auxiliary waypoints. The success rate, or the amount of savings observed vs. the amount of savings attempted, is somewhat higher for direct route DWRs vs. DWRs with auxiliary waypoints. Attempted direct routes realized 57% of attempted savings or 481 min for 33 flights. Attempted routes with auxiliary waypoints realized 42% of attempted savings or 153 min for 11 flights. This indicates a 15% increase in potential savings since auxiliary waypoints are not expected to introduce additional workload when using Data Comm.

Of the 70 attempted route corrections indicated in Figure 5, 44 flights had observed route amendments where flight-time savings totaled to 1 min or more. The elapsed time between the time at which the AA dispatcher accepted the route correction and the time of the first observed amendment with significant savings (more than 1 min) is a measure of processing delay. For the 44 flights, the mean processing delay is 11.9 min, and the standard deviation is 6.8 min. With Data Comm, the success rate indicated in Figure 5 and the processing delays would likely improve resulting in more savings. The additional savings and the reduction in processing delays enabled by Data Comm is part of future research.

If a DWR alert sounded at the dispatcher's workstation, and a button press auto-loaded the DWR into a graphic display with a preformatted ACARS message, then likely many more DWR advisories would be uplinked to flight crews in a timely manner. The reduction in pilot and controller workload needed to evaluate and implement DWR routes would likely enable more DWRs to be processed and more savings for the flights.

Data from the AA trial provides a rough estimate of the additional savings that may be achieved through the use of Data Comm. The total advised savings for AA flights from Jan 2013 to Sept 2104 is 62,899 minutes [4]. If we assume that Data Comm enables all DWR advisories to be uplinked to flight crews, and assume the same success rates (62% airline acceptance and 37% ATC acceptance) describe previously under *Trial at American Airlines*, then the estimated savings for one airline at one Center rises from 3,290 min to 14,429 min – about a 4-fold increase in savings compared to our voice-based trial results. And the ease of controller and pilot communications under Data Comm would likely make the 37% ATC acceptance rate rise, so the savings could be even greater.

DWR Compatibility with Data Comm

The DWR route correction format shown in Figure 1 is compatible with the route clearance message types available for datalink communication on all FANS-1/A CPDLC equipped aircraft. The UM79 route clearance message is well suited to DWR because it defines only the proposed changes to the current route of flight. The UM79 message format and its application to the DWR route correction as shown in Figure 1 are:

UM79 Route Clearance
CLEARED TO [FIX] VIA [ROUTE CLEARANCE]
CLEARED TO [CAPFIX] VIA [MSP..AUXWPT]

A UM79 message preformatted with a DWR route correction could be sent via ACARS from an airline operations center to a FANS-1/A equipped aircraft. In this case the message is sent as a proposed route change. A chime in the cockpit sounds alerting the pilot to the receipt of the uplink message. The pilot then presses a button to load the route correction into the FMS for viewing only without executing the route change. This press-to-load action enables the pilot see the current route of flight, the proposed route change, and weather radar information all on one integrated graphic display. Shown in Figure 6 is the navigation display of FANS-1/A-equipped cockpit after the pilot has loaded a proposed route change into the FMS. The display shows the current route (track-up), the proposed route with an inserted auxiliary waypoint (dashed line), and the weather radar. All aircraft that fly oceanic routes are equipped with FANS-1/A CPDLC and likely many more aircraft will be equipped when Data Comm becomes available in domestic en route airspace.

Figure 6. 747-400 Navigation Display Showing Route Loaded but not Executed

Operating Concepts

In this section two operating concepts that integrate DWR with Data Comm are described. The first leverages DWR automation to find common route corrections for multiple flights, and assumes FAA plans for integration of Airborne Reroutes with Data Comm [5, 6]. The second assumes DWR route corrections are preformatted as CPDLC route changes and uplinked from an airline dispatcher to equipped aircraft, and assumes FAA plans for Pilot-Initiated route changes via Data Comm. Concept 1 aligns with Data Comm Segment 1, Phase 2 (S1P2); Concept 2 aligns with Segment 1, Phase 3 (S1P3) [5].

Concept 1: ATC Initiated via Airborne Reroutes and Data Comm

Figure 7 shows a sample case where DWR route corrections for three flights destined for Chicago are converted to a common route correction for all three flights. In this case each flight indicates about 19 min potential flight time savings. If the automation could identify opportunities like this and present them to Center Traffic Management Coordinators (TMCs), TMCs could use the Traffic Flow Management System automation, Airborne Reroutes and Data Comm to simplify the evaluation, coordination, and clearance delivery process. This could result in more weather avoidance routes being corrected dynamically as weather changes and more efficient operations during weather events.

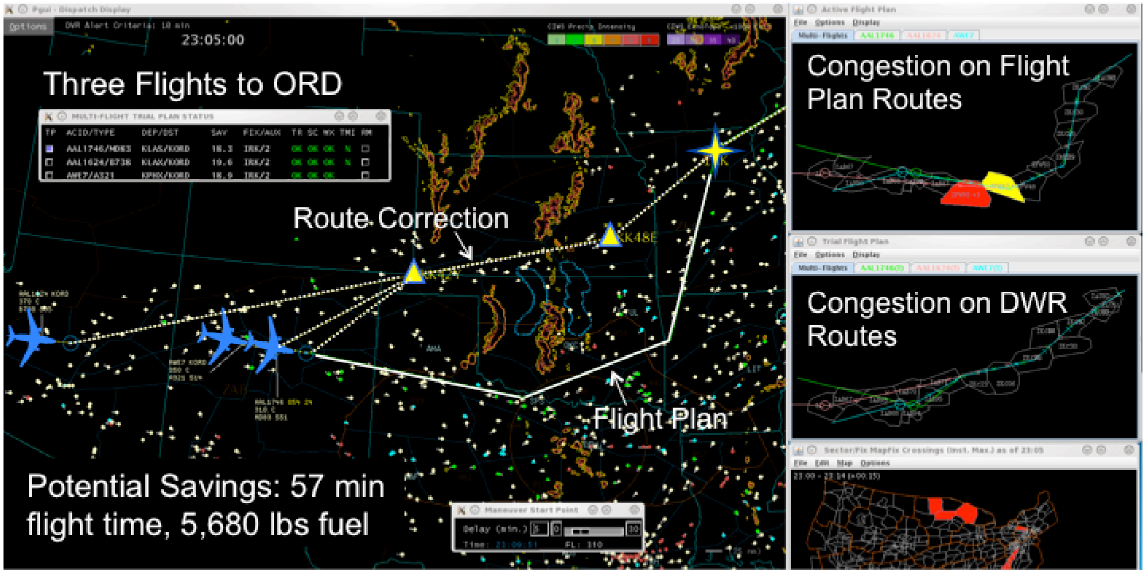

Figure 7. Multi-Flight Common Route Correction

The system components, information flow, and user actions for Concept 1 are depicted in Figure 8. Trajectory automation identifies a common route correction for multiple flights in a single Center and presents an alert on a display in the Center Traffic Management Unit (TMU). The flights are likely in relatively close proximity to one another (about 200-300 miles), are flying on roughly the same course heading, and are destined for a common airport or nearby airports. As in the Figure 7 example, common auxiliary waypoints are selected and adjusted to balance separation from weather and potential flight time savings for all flights. Common auxiliary waypoints and the maneuver start point for each flight may be adjusted to avoid congested sectors, dense merging traffic streams, and restricted airspace. Auxiliary waypoints could also be adjusted to simplify required ATC coordination without significantly impacting opportunity for flight time savings.

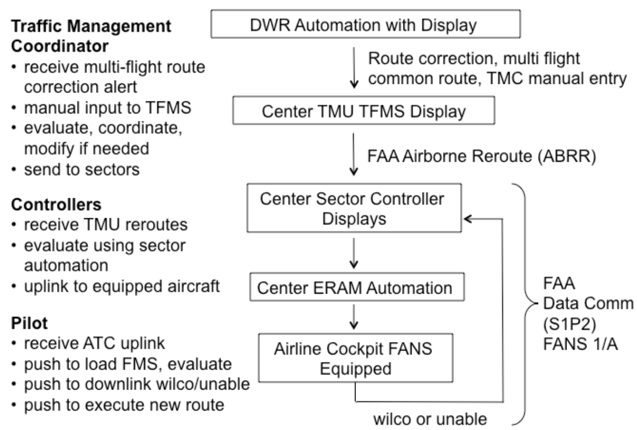

Figure 8. ATC Initiated Multi-Flight Route Correction via ABRR and Data Comm

The minimum potential savings alert criterion, defined perhaps in terms of total potential savings or average potential savings per flight, is adjustable by TMC users. An audible tone (like the DWR ka-ching) alerts TMCs to the presence of a route correction with significant potential for savings. Initially, a TMC manually enters the proposed routecorrection into TFMS automation and selects the proposed flights for analysis. The TMC then evaluates the route correction and performs any necessary coordination and/or modifications to the route change. Later, DWR automation is integrated with TFMS automation so that manual entry of route correction opportunities is not required. The TMC sends the route correction for all flights to the appropriate sectors using ABRR. ABRR automates and simplifies the process of transferring route changes from the TMU to sector controllers [6]. The sector controller presses a button to auto-load the route change sent from TMU into their sector automation for viewing and evaluation. If the aircraft are Data Comm-equipped, the controller presses another button to uplink the route clearance to the pilot. A chime in the cockpit alerts the flight crew to an ATC uplink message, and a button press loads the uplinked route change into the FMS. The flight crew gets a graphic display like that shown in Figure 6, and, if the route change is acceptable, additional button presses send a wilco response to ATC and execute the route change in the FMS.

Concept 1 dovetails nicely with the FAA's Strategic Flow Management Application (SFMA) project that is intended to provide traffic managers, e.g., TMCs, with integrated capabilities to manage flight trajectories more effectively and efficiently in the 20 to 90-minute planning horizon [10]. SFMA builds on ABRR and Data Comm. SFMA includes capabilities to identify dissipating Traffic Flow Management (TFM) constraints, identify flights that could benefit from more efficient trajectories, and develop efficient trajectory changes that balance NAS constraints with flight operator preferences.

A number of simulations at NASA have explored concepts that integrate ground-based trajectory automation with FANS-1/A CPDLC for datalink communication between pilots and radar controllers, and for automated communication between TMCs and radar controllers [11, 12]. One interesting outcome was that radar controllers today might be reluctant to issue significant route changes during weather events without pre-coordination with their Center TMU. But if a big route change comes from the TMU, controllers are more likely to issue the clearance straight away because they know that the necessary downstream coordination has been completed.

Concept 1 could include route correction opportunities for individual flights in certain cases. For example, DWR automation is currently being leveraged to aid merging arrivals and metering during weather events [13]. One element of this work is to automatically identify airborne flights where dissipating weather has opened up opportunities for more efficient arrival routings to the destination airport. For example, a DFW-bound flight approaching ZFW airspace from the north-west may have been routed to the south-west arrival into DFW due to weather forecasted at the more preferred north-west arrival fix. The automation continuously examines arrival trajectories and finds cases where a flight may be moved to its preferred arrival routing because the arrival routing is no longer impacted by weather. A TMC could be alerted to such opportunities and send a message to the first ZFW controller to take control of the flight, or even to a controller further upstream if able. The controller could then immediately get the flight rerouted to the preferred arrival routing. Opportunities like this have been observed during weather events impacting DFW arrival traffic. While some aircraft get routed onto the preferred arrival, others stay on the less preferred route when they likely could have been moved to the preferred route and realized significant savings [13].

Concept 2: Dispatcher/Pilot Initiated via Data Comm

The system components, information flow, and user actions for Concept 2 are depicted in Figure 9. Concept 2 is similar to the DRW operating concept in place at AA, but adds Data Comm to streamline communication and reduce workload, which should result in more savings. DWR automation identifies a route correction for a flight and sends an alert to the dispatcher in charge of the flight. A simple entry on the dispatcher display provides a graphic display of the proposed route and auto-loads the route correction into a preformatted CPDLC route clearance message for uplink to a FANS-1/A equipped aircraft via ACARS. The dispatcher evaluates the proposed route correction using existing automation and, if able, uplinks the preformatted ACARS message to the flight.

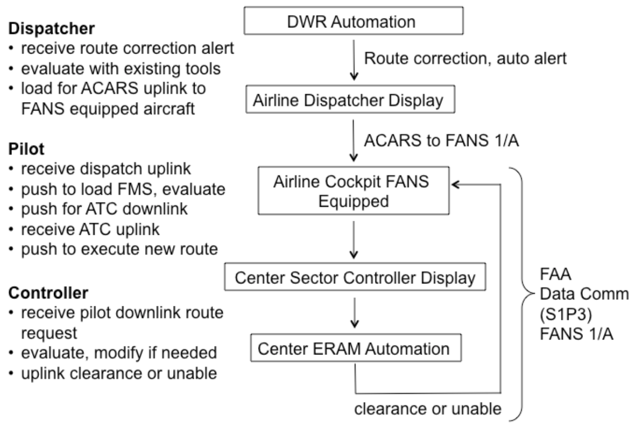

Figure 9. Dispatcher/Pilot Initiated via Data Comm.

A chime in the cockpit alerts the pilot to the receipt of the uplink message. The pilot presses a button to load the route correction into the FMS for viewing only without executing the route change. If the flight crew concurs with the proposed route correction, a button press downlinks the route to the sector controller which is Data Comm-equipped. A downlink message appears in the flight data block or elsewhere on the controller's traffic display, and a simple entry allows the controller to auto-load the downlinked route change request into their own trial planning function to visualize and evaluate the route request. If the controller approves the route change request, a single entry uplinks an approval in the form of a CPDLC route clearance message back to the aircraft. Clearly the controller/pilot communication in Concept 2 is very similar to that of Concept 1, except in Concept 1 the route change originates from ATC while in Concept 2 the route change originates from the dispatcher at the airline operations Center.

Airline / ATC Coordination

DWR automation like that described under Concept 1 could run in both the airline operations center and the en route Center TMU. In the airline operations center, the alerts would be filtered to display only own-airline flights. Common route corrections for multiple flights could be presented to an airline ATC coordinator or dispatcher as in the current AA trial. A communication link between the airline operations center and the en route Center TMU would enable the airline to send a reroute request for a group of the flights to the Center TMU. Minimum savings criteria and route adjustments to account for congestion, coordination, restricted airspace, and other factors could tailor the multi-flight route correction before it is sent from the airline operations center to the Center TMU.

The TMC responds to the multi-flight request just as described under Concept 1 and if able sends the route changes to the appropriate sector controllers using ABRR. The flight crews get the route correction clearances via Data Comm, and the route corrections are pre-coordinated with their airline operations center. As described previously, for significant route changes, the flights are more likely to get route clearances quickly if they come from the Center TMU.

Concluding Remarks

DWR has demonstrated the ability to identify opportunities for large flight-time savings in en route airspace during weather events. Operational testing at AA has shown that some of these opportunities result in significant flight time and fuel savings.

DWR route corrections are well suited to Data Comm. Test results suggest that Data Comm could potentially enable a 4-fold increase in actual savings for one airline in one Center compared to that seen in today's voice-based DWR operations.

Data Comm could greatly simplify the communication and coordination required to implement dynamic updates to weather-avoidance routes, and thereby enable more efficient NAS operations, less delay, and more fuel savings.

Automation and operating concept ideas for integration of DWR with Data Comm have been described. Future research including simulations and operational testing could validate the automation, concepts, and benefits, and demonstrate how smart integration of trajectory automation with Data Comm could save flight time and fuel and improve the efficiency of NAS operations during convective weather events.

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